TWO-DIMENSIONAL OPTICS ELEMENT FOR CORRECTING ABERRATIONS

CROSS-REFERENCE TO A RELATED APPLICATION

This is a continuation-in part application of Ser. No. 261,315, filed May 1, 1981, now abandoned.

BACKGROUND

The present invention relates generally to planar optical systems and more particularly to planar optical systems utilizing geodesic lens elements.

Recent developments in the integrated optics field have resulted in the design and development of integrated optic spectrum analyzers, and the like. A typical spectrum analyzer device is described in a publication by M. K. Barnoski et al entitled "Design, Fabrication and Integration of Components for an Integrated Optic Spectrum Analyzer", 1978 Ultrasonic Symposium Proceedings, IEEE, pages 74–78. The basic integrated optic spectrum analyzer comprises a laser source which transmits light along a planar waveguide layer deposited on the surface of a substrate. Geodesic lenses are disposed in the substrate and the waveguide layer conforms to the contour of the substrate. For example, a geodesic lens collimates laser light through a surface acoustic wave device which deflects the collimated laser beam in proportion to the strength or frequency of the signals applied to the surface acoustic wave device. After the laser light passes through the surface acoustic wave device, a second geodesic lens refocusses the light onto a photoelectric detector array.

Heretofore, in order to insure that the laser source and detector array were precisely located at the focal planes of the geodesic lenses, it was necessary to remove excess material from the ends of the substrate and waveguide layer prior to locating the laser source and detector elements. The shortcomings of this approach are that it cannot correct for lenses with focal lengths in excess of the platelet dimension; that is, where substrates and waveguide layers are shorter than the focal length of the geodesic lenses. Fabrication of the geodesic lens system, therefore, is only a one-way method. The platelet may be shortened to properly place the laser source or detector array at a focal plane of the geodesic lens located on the structure. Shortening of the platelet changes the over-all dimensions of the spectrum analyzer in an uncontrollable manner leading to assembly and installation problems.

Therefore, it would be an improvement in the integrated optics art to provide a means by which to adjust the positions of focal planes of lenses utilized in a geodesic lens system, or the like, without changing the dimensions of the structure.

It would also be an improvement in the integrated optics art to provide a means by which to correct for optical aberrations in a planar waveguide system which defocus light rays transmitted by the system.

SUMMARY OF THE INVENTION

In order to overcome the above mentioned shortcomings, the present invention provides for an optical element which is utilized in conjunction with an integrated optic device which employs geodesic lenses, such as an integrated optic spectrum analyzer. The integrated optic device has a substrate into which is disposed a geodesic lens, and onto which is disposed a planar surface layer, or waveguide, for transmitting light therethrough. The surface layer conforms to the contour of the substrate and light is transmitted in the plane of the waveguide from a source to a detector. The improvement comprises an optical element including an auxiliary surface depression disposed on the substrate having a predetermined depth and contour. The depression may be symmetrical about a predetermined longitudinal axis of the surface layer and is generally cylindrical in shape. This optical element increases the length of the path of light transmitted or intercepted by the geodesic lens so as to reposition the focal plane of the geodesic lens at a predetermined position closer to the lens. Alternatively, nonspherical depressions having complex geometric curvature may be provided which correct for optical aberrations in the integrated optic device by focusing divergent light.

In an integrated optic spectrum analyzer device, the present invention provides for an increase in path length of the light transmitted along the surface layer. This increased path length allows the focal plane of a lens to be adjusted so as to have the focal plane at either the input position of the laser source or the output position of the detector array without modifying the substrate dimensions. In addition, aspheric lens designs or lenses with complex curvatures may be incorporated as the optical element allowing the light to be focused in a manner which corrects for abnormalities in the planar optical system.

BRIEF DESCRIPTION OF THE DRAWINGS

The aforementioned features and advantages of the present invention may be more readily understood with reference to the following detailed description taken in conjunction with the accompanying drawing, wherein like reference numerals designate like structural elements, and in which:

FIG. **1** is an embodiment of an integrated optic spectrum analyzer incorporating optical elements in accordance with the present invention;

FIGS. **2, 3** and **4** show alternative aspheric lens optical element designs which may be utilized in the spectrum analyzer of FIG. **1**.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. **1**, there is shown an integrated optical spectrum analyzer **20** which comprises a substrate **26** and a planar surface layer **27**, or waveguide, disposed thereon. The substrate **26** comprises a nonlinear optical material for active devices but can be any transparent optical material for passive devices. A laser source **21**, such as a solid state or injection laser, or the like, is disposed at one end of the substrate **26**. A detector array **24** and a reference cell **28** are disposed at the opposite end of the substrate. The detector array **24** may be a CCD array or the like. Two geodesic lenses **22, 23** are disposed in the substrate **26**. These lenses **22, 23** are fabricated by means of well-known methods, such as are described in publication by B. Chen et al, entitled, "Diffraction Limited Geodesic Lens for Integrated Optics Circuits", *Applied Physics Letters* 33(6), Sept. 15, 1978. The lenses **22, 23** are generally fabricated by means of an ultrasonic impact grinding or a computer controlled polishing device which polishes the surface of the substrate **26** to the desired depth and contour. The lenses **22, 23** are designed to collimate the